Europäisches Patentamt
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(11) Publication number: **0 217 985 A1**

EUROPEAN PATENT APPLICATION

(21) Application number: 85306408.7

(51) Int. Cl.⁴: **H02H 9/04**

(22) Date of filing: 10.09.85

(43) Date of publication of application: 15.04.87 Bulletin 87/16

(84) Designated Contracting States: AT BE CH DE FR GB IT LI LU NL SE

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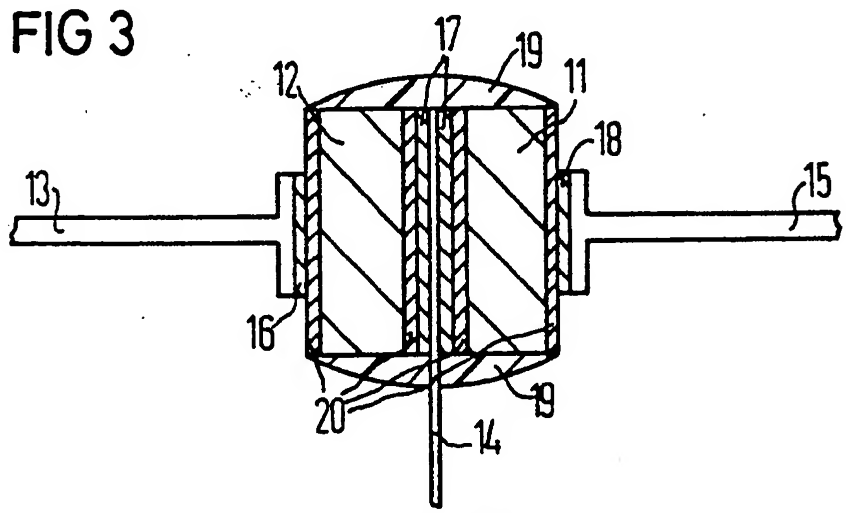
(54) Transient suppression system.

(57) A transient suppression system comprising at least one transient suppressor for clamping short duration pulse voltages and a further device comprising at least one positive temperature coefficient thermistor (12) for controlling the electrical power input to said at least one transient suppressor (11) should be improved. At least one transient suppressor (11) is placed in intimate thermal contact with at least one of the positive temperature coefficient thermistors (12).

FIG 3



EP 0 217 985 A1

Transient Suppressi n System

This invention relates to a transient suppression system comprising at least one transient suppressor for clamping short duration pulse voltages and a further device comprising at least one positive temperature coefficient thermistor for controlling the electrical power input to said at least one transient suppressor thereby preventing longer duration fault conditions damaging said transient suppressor.

A transient absorption semiconductor device - (transient suppressor) presents a relatively high impedance over a given range of applied voltage and a low impedance in response to transient voltage excursions from the given range, the device having particular application as a protection device in an electrical circuit, for protecting the circuit by selectively conducting transient surges in current flowing in the circuit.

It is known that a PN junction in a semiconductor body can be used to protect an electrical circuit from transient voltage surges. The PN junction is connected across a voltage supply to the circuit such as to be reverse biased. The breakdown voltage of the reverse biased junction is selected to be somewhat greater than the voltage normally developed by the supply. Thus in normal use, the junction does not conduct substantially but in the event of a transient voltage surge which results in the supply voltage exceeding the breakdown voltage, the reverse biased junction breaks down and conducts the current surge associated with the voltage surge, so as to protect the circuit from the surge. The breakdown voltage is typically in the range 2 -1000 V the value thereof being selected for the junction concerned by control of the doping levels utilised in manufacture of the junction. For higher voltages in the aforementioned range of breakdown voltages the breakdown occurs by virtue of the Avalanche effect whereas at lower voltages the Zener effect may predominate.

Typically the current flowing in the reverse biased junction prior to breakdown is of the order of 1 -10 µA whereas after breakdown, heavy current surges with peak currents of 25 amps or more may flow.

Transient suppressors are frequently used in connection with fuses in surge protection circuits such as that shown in Figure 1. The transient suppressor 1 is used to clamp short duration pulse voltages with time constants in the range 10 nsec to 10 msec. These voltages can reach 5000 V and the associated curr nts 5000 amps. The fuse 2 is used to prevent longer duration fault conditions damaging the transient protector 1 and thereafter subsequent electronic devices in th system.

The fuse 2 controls the lectrical power input to the transient suppressor 1. The transient suppression system of Figur 1 has the input 7 and th output 8.

Figure 2 shows two such circuits as shown in Figure 1 in a configuration often used in telecommunications applications. The transient suppression system of Figure 2 comprises two transient suppressors 3, 5 and two fuses 4, 6, the two transient suppressors 3, 5 having one common terminal which is set on a reference potential.

Instead of fuses positive temperature coefficient thermistors have been used for this application as they are unaffected by short time constant current and voltage transients. Such a transient suppression circuit offers a high degree of protection to subsequent components and operates well under a wide range of fault conditions. There is however a range of long time constant surges which are too low in current to affect the thermistor resistance but large enough to cause excessive dissipation in the transient suppressor device. These can lead to degradation of the transient suppressor device and the circuitry it is protecting.

The present invention provides an improved transient suppression system in which the aforementioned disadvantages are overcome. At least one transient suppressor is placed in intimate thermal contact with at least one of the positive temperature coefficient thermistors.

The transient suppressor device is placed in intimate thermal contact with the positive temperature coefficient thermistor. This allows heating of the transient suppressor device over the temperature at which the thermistor resistance exhibits large changes (~100 °C) to result in current limiting. This current limiting effect will protect both the transient suppressor device and the subsequent circuitry from damage.

Those skilled in the art will readily be able to determine from the following explanations and by routine trial and experiment suitable junction configurations and doping levels which produce this decrease in voltage upon breakdown of the reverse biased junction.

Whilst, as will hereinafter be discussed, variation of one or more of the manufacturing parameters of the transient suppression system according to the invention enables systems to be manufactured consistently and reliably with breakdown voltages within a relatively wide range and up to relatively high values of the order of 150 to 200 V for example. For applications in the higher voltage areas the invention further proposes, rather than the provision of a single transient suppressor, to

couple together in series two or mor transient suppressors each of a lower breakdown voltage rating. The resultant composite system has a breakdown voltage substantially corresponding to the sum of the breakdown voltages of the individual transient suppressors of the composite multi-device structure.

In order that th invention may be more fully understand embodiments thereof and their operating characteristics will won be described by way of illustrative example and by way of contrast with prior art systems, reference being had to the accompanying drawings wherein:

Figures 1 and 2 show prior art transient suppression systems;

Figure 3 shows a transient suppression system according to the invention;

Figure 4 shows the electrical circuit elements of the transient suppression system according to Figure 3.

Figure 3 shows one application of the invention. A transient suppressor device 11 type L5C 150 CD manufactured by Semitron Cricklade Ltd, Cricklade Swindon, Wiltshire SN6 6HQ, GB, is soldered to a positive temperature coef ficient thermistor 12 type manufactured by STC Components, GB. The transient suppressor device L5C 150 CD is of a type known as a foldback device (European Patent Application 82 304 718.8 = EP 0 088 179 A and US-Patent application Ser. No. 418 357).

Such a foldback device comprises a body of semiconductor material including a region of a first conductivity type disposed between regions of opposite conductivity type so as to define first and second spaced apart semiconductor rectifying junctions, first and second electrodes so arranged that when a potential difference is applied thereto one of said junctions is forward biased and the other of the junctions is reverse biased, the junctions being disposed to interact in such a manner that upon breakdown of the reverse biased junction from a relatively low conductivity state to a relatively high conductivity state and with an increase in the magnitude of the current flowing through the device, the magnitude of the potential difference developed across the electrodes decreases from that which causes said breakdown but does not decrease to a value less than a given non-zero value.

For an applied voltage V up to a given breakdown voltage V_b , the current flowing through the foldback device is the foldback device leakage current which is very small, for example 5 μA, and this has a significant effect on the operation of the circuit being protected. In this situation, one PN junction is forward biased, and the other PN junction is reverse biased but not such as to exceed its breakdown voltage.

When a voltage transient occurs in the supply voltag V, such as to apply to the device a voltag exceeding V_b, the reverse biased junction breaks down and conducts by means of the Avalanch effect. Consequently, the foldback device then provides a conductiv path for surge currents produced by the voltage transient, and the surge currents thus by-pass th circuit to be protected to prevent it being damaged. As the surge current increases, the voltage developed across the device rapidly reduces from the foldback device breakdown voltage V_b to a predetermined non-zero value V_m and as the current increases further, the voltage remains at the value V_m at least over a considerable range of surge current.

The voltage V_m may be selected by means of the doping process used to make the device and principally by control of the proximity to one another of the two PN junctions by control of the dopant diffusion depths and will be selected in dependance upon the characteristics of the circuit to be protected to be in excess of the minimum safe supply voltage for the circuit being protected.

Such a foldback device 11 is designed to breakdown at approximately 160 V. The voltage across the device 11 is then reduced to approximately 100 V due to the "foldback" action of the device 11.

The thermistor 12 is designed to change from a low resistance state (20 ohms) to a high resistance state (20 kohm) by heating from 100 °C to 150 °C. The assembly has three terminals 13, 14, 15 soldered to it with solder 16, 17, 18, and is coated with silicone rubber 19 to passivate the semiconductor junctions and to prevent flashover. Metal electrodes 20 are placed between the solder 16, 17, 18 and the respective surfaces of the devices 11, 12 in order to improve the electrical contact between the terminals 13, 14, 15 and the devices 11,12.

The resultant composite device has the circuit elements shown in Figure 4. One such device is required for the circuit shown in Figure 1 and two such devices are required for the circuit shown in Figure 2.

The terminals 13, 14 of the device of Figure 3, 4 are supplied with the electrical input and the terminals 14, 15 yield the corresponding electrical output.

An assembly of the type depicted in Figure 3 has shown excellent powers of circuit protection. The thermistor 12 protects against continuous excessive current. The transient suppressor 11 protects against short time constant surges. The thermistor 12 also reacts to excessive temperature due to power dissipation in th transient suppressor device 11. Th combined unit therefore acts as a protector in intermediate fault conditions. Such be-

haviour was observed when subjecting the device to a 200 mA/240 V AC fault current for a duration of 5 minutes. If th thermistor 12 and transient suppressor 11 were not placed in thermal contact, the transient suppressor 11 would be degraded by this condition. The new innovative device limited the current to prevent excessive t mperature rise in the transient suppressor device 11.

The transient suppression system does not only apply to Zener diode based Semiconductor devices, but can apply to other transient suppressor devices such as gas discharge tubes and thyristor based protectors.

Claims

1. Transient suppression system comprising at least one transient suppressor for clamping short duration pulse voltages and a further device comprising at least one positive temperature coefficient thermistor for controlling the electrical power input to said at least one transient suppressor thereby preventing longer duration fault conditions damaging said transient suppressor

characterized in that

at least one transient suppressor is placed in intimate thermal contact with at least one of the at least one positive temperature coefficient thermistors.

2. Transient suppression system according to claim 1, characterized in that

at least one transient suppressor is soldered to at least one of the at least one positive temperature coefficient thermistors.

3. Transient suppression system according to claim 1 or 2,

characterized in that

at least one positive temperature coefficient thermistor is designed to change from a low resistance state to a high resistance state by heating from 100 °C to 150 °C.

4. Transient suppression syst m according to one of the claims 1 to 3,

characterized in that

at least one transient suppressor is designed to breakdown at approximately 160 V.

5. Transient suppression system according to claim 4, characterized in that

after the breakdown of the at least one transient suppressor, the voltage across the at least one transient suppressor is reduced to approximately 100 V due to a foldback action of the transient suppressor.

6. Transient suppression system according to one of the claims 1 to 5,

characterized by

three terminals soldered to it.

7. Transient suppression system according to one of the claims 1 to 6,

characterized by

a coating of silicone rubber.

8. Transient suppression system according to one of the claims 1 to 7,

characterized by

at least one Zener diode based Semiconductor device as a transient suppressor.

9. Transient suppression system according to one of the claim 1 to 8,

characterized by

at least one gas discharge tube as a transient suppressor.

10. Transient suppression system according to one of the claims 1 to 9,

characterized by

at least one thyristor based protector as a transient suppressor.

FIG 1

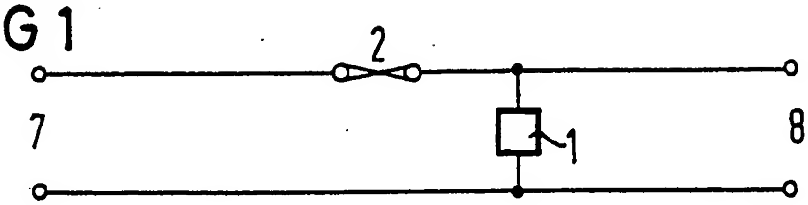


FIG 2

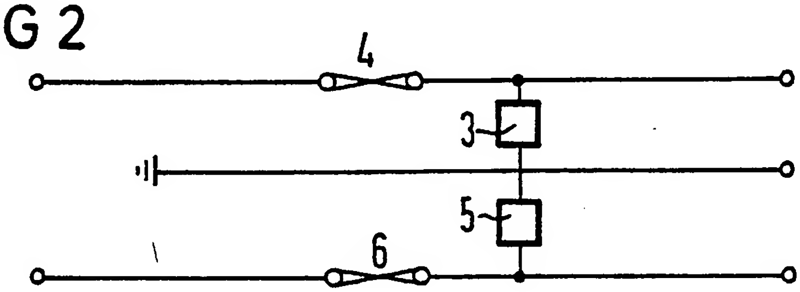


FIG 3

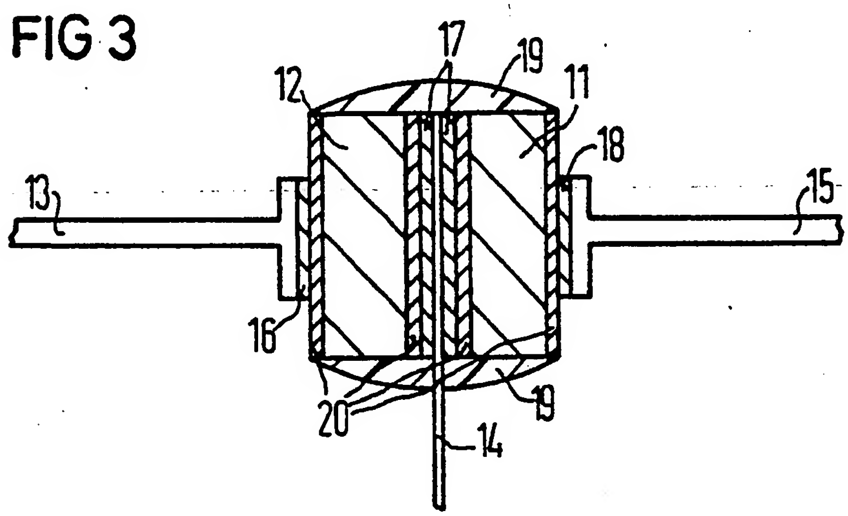
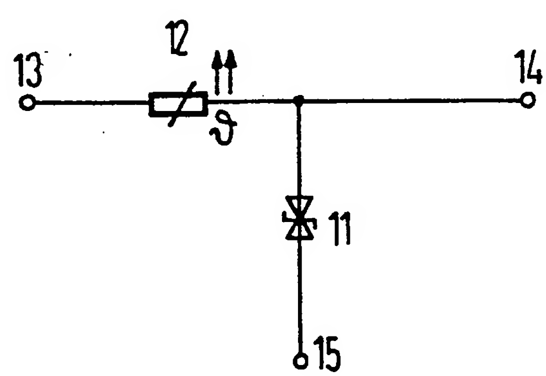


FIG 4



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EUROPEAN SEARCH REPORT

Application number

EP 85 30 6408

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	DE-A-2 405 671 (SIEMENS AG) * claims 1-5, 7; figures 1, 25 *	1,2,8, 9	H 02 H 9/04
A		3-6	

A	EP-A-0 103 180 (SIEMENS AG) * claims 1, 3; figures 1, 2 *	1,3,6	

A	US-A-4 089 032 (W.D. ORFANO) * column 3, line 51, column 4, line 3; figures 1, 4 *	7	

D,A	EP-A-0 088 179 (SEMITRON CRICKLADE LTD.) * abstract; figure 1 *		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
	-----		H 01 L 29/90 H 02 H 9/04 H 02 H 9/06

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	29-04-1986	LEMMERICH J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited f r other reasons

& : member of the same patent family, corresponding document

EPO Form 1503. 03.82

(19) Europäisches Patentamt
European Patent Office
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(11) EP 0 736 950 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.10.1996 Bulletin 1996/41

(51) Int. Cl.[6]: H02H 9/04

(21) Application number: 96104944.2

(22) Date of filing: 28.03.1996

(84) Designated Contracting States:
DE FR GB

(30) Priority: 04.04.1995 IT TO950255

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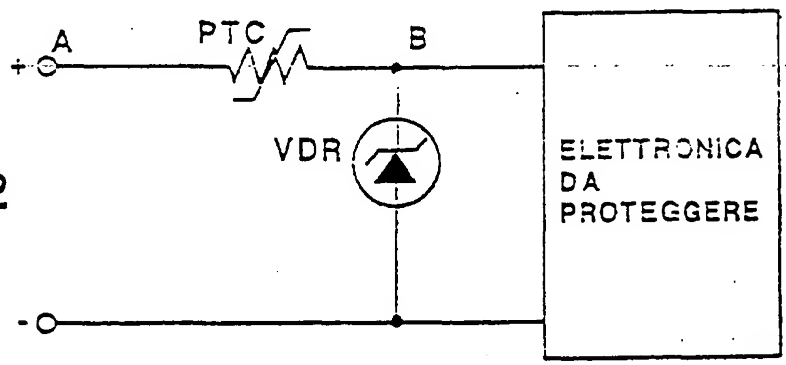
(54) Device for protecting electronic circuits against supply battery disconnection (load dump) and/or overvoltages in the electrical supply circuit of motor vehicles

(57) A device is described for protecting against supply battery disconnection (load dump) and/or transients present in the electrical supply circuit of motor vehicles downstream of the alternator and battery; the main characteristic of the described device is that the device comprises a series thermistor (PTC) and a parallel varistor (VDR).

FIG. 2



EP 0 736 950 A1

Description

This invention relates to a device for protecting against transients present in the 12 Volt electrical supply circuit of motor vehicles, downstream of the alternator and battery. It is well known that all inductive loads, relays, motors, solenoid valves and high voltage coil directly or indirectly induce overvoltages of ± 300 Volts lasting a few microseconds, ± 100 Volts lasting a few milliseconds and, the most destructive of all, the so-called load dump of +80 Volts lasting 400 milliseconds, generated by poor contact or actual disconnection of the battery while the alternator is rotating.

These transients have the power to destroy the various electronic circuits on board if they are not protected individually and effectively.

Electronic components for this purpose have been commercially available for some time, but because of the large currents concerned and hence the considerable dissipation, they are very bulky physically if correctly dimensioned, and in addition are very costly.

The object of the present invention is to provide a device for protecting against the transients present in the 12 Volt electrical supply circuit of motor vehicles which represents an improvement over known devices.

This object is attained according to the present invention by a device for protecting against supply battery disconnection (load dump) and/or transients present in the electrical supply circuit of motor vehicles downstream of the alternator and battery, characterised by comprising a thermistor connected in series with, and a varistor connected in parallel with, the electronic circuit to be protected.

Further characteristics and advantages of the present invention will be apparent from the description given hereinafter with reference to the accompanying drawings, which are provided by way of non-limited example and in which:

Figures 1 and 1A are schematic representations of known devices;
Figure 2 shows the electrical schematic of a protection device according to the invention;
Figure 3 represents the curve of voltage against time for the protection circuit of Figure 2;
Figure 4 is a schematic representation of a known protection device;
Figure 5 shows the electrical schematic of a protection circuit according to the invention;
Figure 6 shows the electrical schematic of a modification of the protection circuit of Figure 2.

The protection device of the present invention has been designed for use in small-dimension circuits in which because of the particular application it is not possible to limit the current in the downstream circuit by resistors in series with the supply (see Figure 1A) because of the high voltage drop which would result from the nominal current absorbed by the circuit.

As can be seen from the schematic of Figure 2, the device of the present invention is composed of a PTC thermistor of very low ohmic value (0.5 - 1 Ω), chosen on the basis of the nominal current, and a VDR varistor with a clamp voltage of less than 40 Volts (maximum voltage acceptable by normal 12 Volt electronic circuits used in the automobile field) and with a current capacity for very short times which is much lower than necessary, and is hence of very small physical dimensions. These characteristics of the VDR varistor are chosen as if it were mounted with high-value resistors in series (see Figure 1A).

In the presence for example of a load dump of + 80 Volts lasting 0.400 seconds, the peak current through the PTC thermistor is very high and much higher than its rated current. The VDR varistor, which acts as a power zener, short-circuits the applied voltage difference via the PTC thermistor to the negative pole of the battery. The PTC thermistor, traversed by high current, instantaneously reaches its trip point.

Because of its positive temperature coefficient, the PTC thermistor increases its resistance by 20-30 times, reducing the current across the VDR varistor to a minimum value. In any event, the VDR varistor need be dimensioned to withstand high peak currents for only a few milliseconds, instead of for some hundreds of milliseconds.

To obtain the same protection with the VDR varistor alone, as in the prior art (Figure 1), the physical dimensions of this latter would not be less than a disc of 18-19 mm diameter, against a VDR varistor in the circuit of the present invention with a diameter of only 5-7 mm. The diameter of the PTC thermistor is also about 5-7 mm

The best results are obtained with very fast PTC thermistors designed for use as resettable thermofuses of conductive polymer material. The PTC thermistor must be chosen such as to have a trip current of at least double the required rated current, taking also account of the temperature range within which it is used. Figure 3 shows by oscillograph the action of the protection circuit according to the invention when a load dump pulse of + 80 V is applied to it.

In the oscillogram of Figure 3, CH1 indicates the voltage at point B of Figure 2 and CH2 indicates the voltage at point A (load dump pulse applied).

As can be seen, after a fluctuation of a few milliseconds at about 40 Volts the voltage stabilizes at about 35 Volts (clamping effect of the VDR varistor) to then fall to the normal supply voltage of 12 Volts. Applying the circuit of Figure 2, in which the PTC thermistor is in series, further protection is obtained. In the case of short-circuiting of the downstream electronic circuit, the PTC thermistor increases its resistance to a high value, so preventing short-circuiting of the supply line towards the battery.

Figure 4 shows the known schematic for protecting against reversal of the supply voltage normally required by electrical circuits used in motor vehicles.

As can be seen, to achieve this object it is sufficient to add a diode (D1) of adequate value, in series with the feed resistor R1, to the device of Figure 1A. However the provision of a diode in series causes a further voltage drop of at least 0.8-0.9 Volts, which is not always acceptable by the downstream electronic circuitry.

The circuit of Figure 5 shows that the use of the device of Figure 2 enables protection against supply voltage reversal to be also added, by connecting the diode D1 not in series, but in parallel with the VDR varistor after the PTC thermistor. If reversal takes place, the diode D1 conducts directly and the PTC thermistor instantaneously increases its resistance by the effect of the current (short-circuit current) passing through it.

When the polarity error disappears, the resistance of the PTC thermistor returns to its nominal value, to restore normal operation to the device.

In the schematics of the various accompanying figures, the varistor (VDR) is shown as an encircled zener. Physically the component is generally a disc of sintered metal oxides connected to two rheophores. Its diameter is a function of the maximum current (peak and nominal) which it must withstand on attaining its clamping voltage. To safely overcome transients and the load dump, the component, if used without series resistors, is required to withstand a power dissipation level which requires the use of large mechanical dimensions (diameter and thickness) which are unacceptable in the large majority of applications. The circuit of the invention reliably solves this problem from the mechanical, electrical and cost aspects.

The device of the present invention has also been designed to protect an electronic driver circuit for a small direct current motor, mounted in a reduction unit for automobile use, eg. for operating air entry/recirculation/mixing/distribution flap valves in ventilation units. The nominal and starting current of the motor do not permit the use of resistors in series with the supply because of the large voltage drop which would occur. The device of Figures 2 and 5 solves the problem by using a PTC thermistor of conductive polymer with a constant resistance of only 0.5-1 Ω and a rated working current of 0.5-0.6 Amps. As already described, when protection is required, the resistance increases instantaneously to protect the VDR varistor and the entire downstream electronic circuit (Figure 6).

Instead of being combined with a varistor (VDR), the same device of Figures 2, 5 and 6 can be combined with any other component able to suppress transients (such as a zener diode, a monodirectional silicon suppressor, etc.), provided it is chosen with suitable characteristics for coupling to the PTC thermistor and able to dissipate the instantaneous power required.

The device of the invention has the following advantages:

- the use of a series-connected thermofusible PTC thermistor of low ohmic value enables the protection device to be used in those very high absorption circuits in which similar protection using a VDR varistor but with a fixed resistor in series (see Figure 4) would require for equal VDR dimensions and power a resistor greater than 10 Ω and a power of at least 1 Watt, which would be unacceptable because of the high voltage drop in the circuit in which it is used. It should be noted that with a current of for example 0.1 A in a circuit such as that of Figure 4, the voltage drop is 1 V; in the circuit of the invention shown in Figure 5, for equal current a 1 Ω PTC thermistor results in a voltage drop of only 0.1 V.
- The small diameter of 5-7 mm for each component (PTC thermistor and VDR varistor) allows effective protection in small-dimension mechanical circuits with a large number of components.
- The use of the PTC thermistor also allows protection against short-circuiting to the supply, so avoiding serious possibilities of fire and melting of connection cables.
- The PTC thermistor acts as a self-resettable fuse, which disconnects automatically on eliminating the cause of the fault.
- The small dimensions of the two components eliminate problems of mechanical stress under vibration.
- Elimination of a series-connected diode for protection against supply voltage reversal, so achieving a low voltage drop.

The characteristics of the control device of the invention and its advantages are apparent from the aforegoing description.

Because of its small dimensions, the described device can be easily used in cases in which known devices cannot be connected for space reasons.

The device has been presented with reference to its use in control devices for a flap valve operating motor in a vehicle, but can be equally used, possibly with small modifications, in other applications in which the movement of small d.c. motors has to be protected in a simple manner without problems.

It is apparent that further modifications can be made to the protection device of the present invention without leaving the principles of novelty present in the inventive idea, and moreover in the practical implementation of the invention the materials and shapes of the illustrated details can be different, and that these can be replaced by technically equivalent elements.

Claims

1. A device for protecting against supply battery disconnection (load dump) and/or transients present in the electrical supply circuit of motor vehicles downstream of the alternator and battery, characterised by comprising a thermistor (PTC) connected in series with, and a varistor (VDR) connected in parallel with, the electronic circuit to be protected.

2. A protection device as claimed in claim 1, characterised in that a diode (D1) is connected in parallel with the varistor (VDR).

3. A protection device as claimed in claim 1 or 2, characterised by being connected to protect a control circuit for a flap valve operating motor in a motor vehicle.

4. A protection device as claimed in one or more of the preceding claims, characterised in that the varistor (VDR) is dimensioned to withstand high currents for a few milliseconds.

5. A protection device as claimed in one or more of the preceding claims, characterised in that the thermistor (PTC) has a resistance of only 0.5-1 ohm with a working current of 0.5-0.6 A.

6. A protection device as claimed in one or more of the preceding claims, characterised in that the varistor (VDR) consists of a zener power diode.

7. An electronic protection device, in particular for use in motor vehicles, in accordance with the aforegoing description and the accompanying drawings.

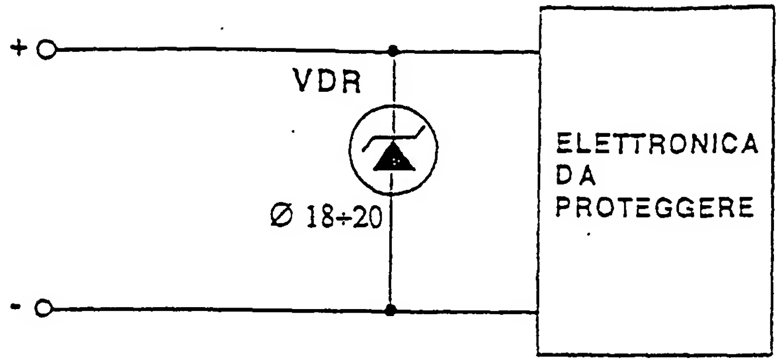


FIG. 1

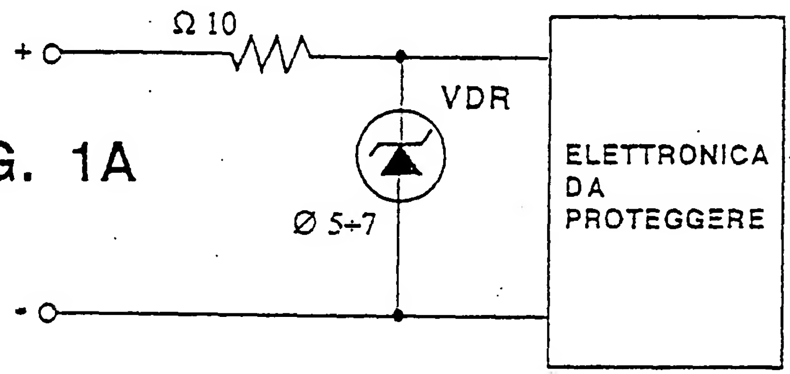


FIG. 1A

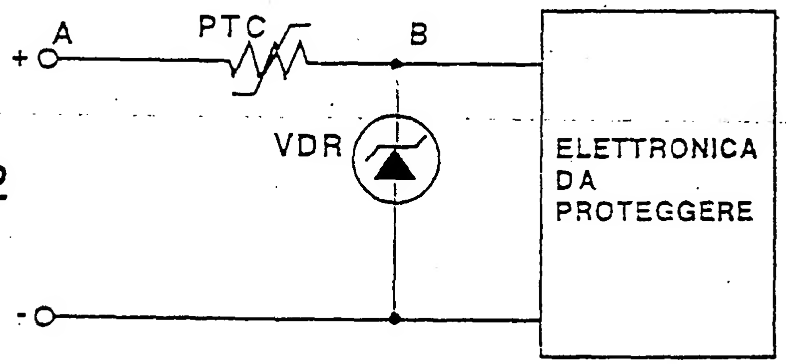


FIG. 2

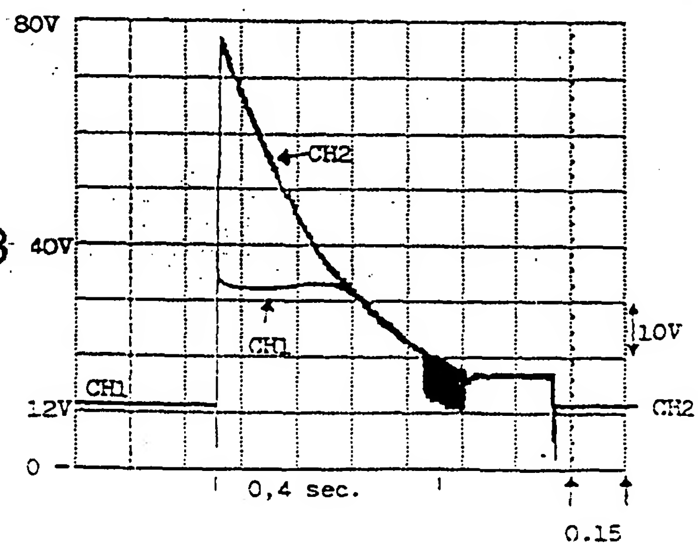


FIG. 3

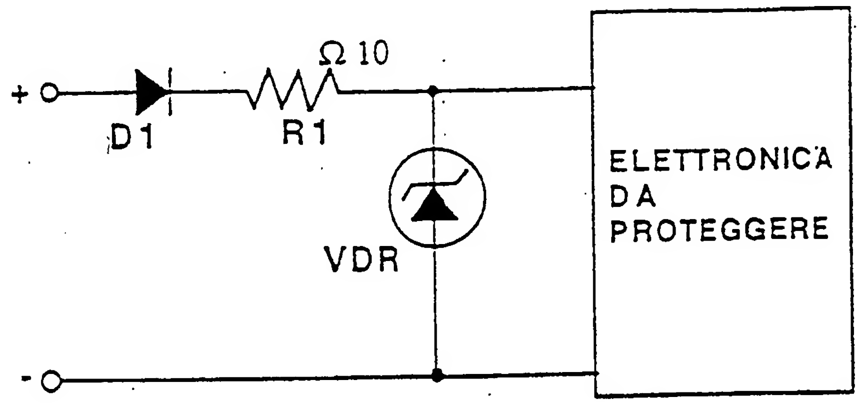


FIG. 4

FIG. 5

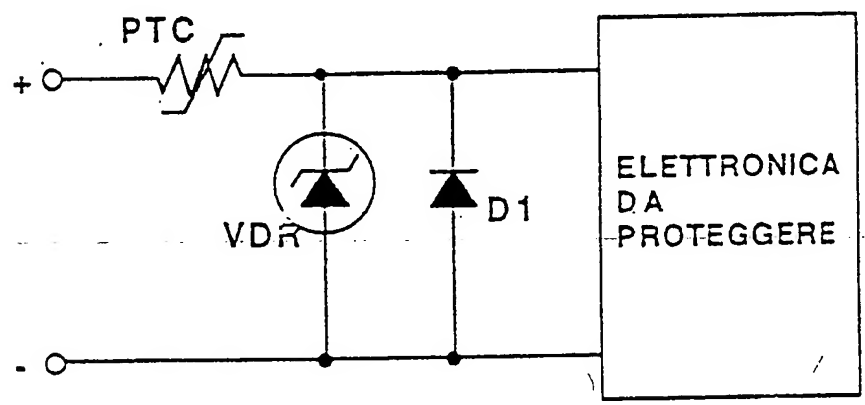
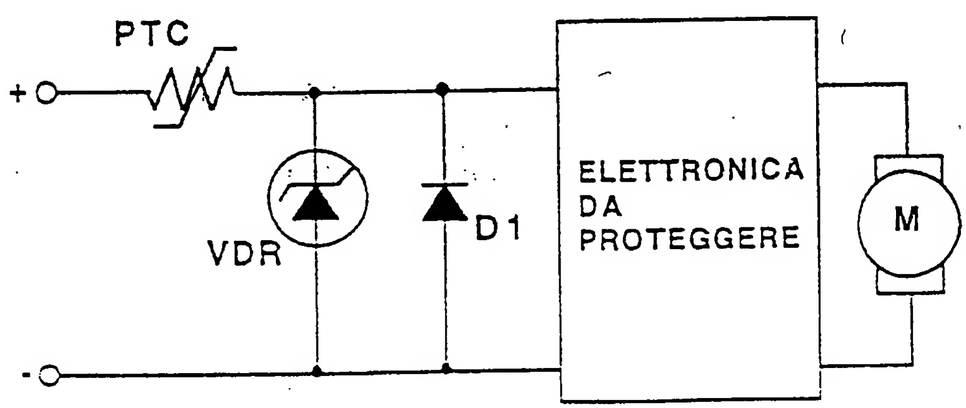


FIG. 6



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EUROPEAN SEARCH REPORT

Application Number
EP 96 10 4944

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	FR-A-2 528 253 (JAEGER) 9 December 1983	1,3,4,6,7	H02H9/04
Y	* page 1, line 8 - line 38; figure 1 *	2	
X	DE-A-39 08 236 (DEHN & SOEHNE) 20 September 1990 * column 3, line 60 - column 4, line 4; figure 1 *	1,5	
X	DE-A-36 21 200 (SIEMENS AG) 7 January 1988 * abstract *	1,4,6	
X	EP-A-0 103 180 (SIEMENS AG ;SIEMENS BAUELEMENTE OHG (AT)) 21 March 1984 * abstract *	1,4,6	
Y	DE-A-32 31 143 (BOSCH GMBH ROBERT) 23 February 1984 * page 8, paragraph 1; figure 1 *	2	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H02H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	2 July 1996	Salm, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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(19) Europäisches Pat ntamt
European Patent Office
Office européen des brev ts

(11) Publication number: 0 217 985 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of the patent specification: 29.11.89

(51) Int. Cl.⁴: H02H 9/04

(21) Application number: 85306408.7

(22) Date of filing: 10.09.85

(54) **Transient suppression system.**

(43) Date of publication of application: 15.04.87 Bulletin 87/16

(45) Publication of the grant of the patent: 29.11.89 Bulletin 89/48

(84) Designated Contracting States: AT BE CH DE FR GB IT LI LU NL SE

(56) References cited:
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Description

This invention relates to a transient suppression system according to the preamble of claim 1.

GB-A 2 093 647 discloses such a transient suppression system.

A transient absorption semiconductor device (transient suppressor) presents a relatively high impedance over a given range of applied voltage and a low impedance in response to transient voltage excursions from the given range, the device having particular application as a protection device in an electrical circuit, for protecting the circuit by selectively conducting transient surges in current flowing in the circuit.

It is known that a PN junction in a semiconductor body can be used to protect an electrical circuit from transient voltage surges. The PN junction is connected across a voltage supply to the circuit such as to be reverse biased. The breakdown voltage of the reverse biased junction is selected to be somewhat greater than the voltage normally developed by the supply. Thus in normal use, the junction does not conduct substantially but in the event of a transient voltage surge which results in the supply voltage exceeding the breakdown voltage, the reverse biased junction breaks down and conducts the current surge associated with the voltage surge, so as to protect the circuit from the surge. The breakdown voltage is typically in the range 2 - 1000 V the value thereof being selected for the junction concerned by control of the doping levels utilised in manufacture of the junction. For higher voltages in the aforementioned range of breakdown voltages the breakdown occurs by virtue of the Avalanche effect whereas at lower voltages the Zener effect may predominate.

Typically the current flowing in the reverse biased junction prior to breakdown is of the order of 1 - 10 μA whereas after breakdown, heavy current surges with peak currents of 25 amps or more may flow.

Transient suppressors are frequently used in connection with fuses in surge protection circuits such as that shown in Figure 1. The transient suppressor 1 is used to clamp short duration pulse voltages with time constants in the range 10 nsec to 10 msec. These voltages can reach 5000 V and the associated currents 5000 amps. The fuse 2 is used to prevent longer duration fault conditions damaging the transient protector 1 and thereafter subsequent electronic devices in the system.

The fuse 2 controls the electrical power input to the transient suppressor 1. The transient suppression system of Figure 1 has the input 7 and the output 8.

Figure 2 shows two such circuits as shown in Figure 1 in a configuration often used in telecommunications applications. The transient suppression system of Figure 2 comprises two transient suppressors 3, 5 and two fuses 4, 6, the two transient suppressors 3, 5 having one common terminal which is set on a reference potential.

Instead of fuses positiv temperature coefficient thermistors have been used for this application as they are unaffected by short time constant current and voltage transients. Such a transient suppression circuit offers a high degree of protection to subsequent components and operates well under a wide range of fault conditions. There is however a range of long time constant surges which are too low in current to affect the thermistor resistance but large enough to cause excessive dissipation in the transient suppressor device. These can lead to degradation of the transient suppressor device and the circuitry it is protecting.

One embodiment of a protection arrangement according to GB-A 2 093 647 has a PTC (Positive Temperature Coefficient-Thermistor) and a VDR (Voltage Dependent Resistor) and a copper plate between the PTC and the VDR. A VDR which is connected on one side (the contacting side) to an other element and which is cooled at the other side (the side which is exposed to the air) by the ambient air, will, since air has a much lower cooling capacity than the material at the contacting side, reach a considerably higher temperature at the side exposed to the air than at the contacting side, when a large quantity of heat is generated in its interior. Thus, it is possible that, at the side exposed to the air, the VDR may be damaged by overheating before its contacting side – and consequently the PTC – has become so hot that the PTC starts performing its current-impeding function. To limit the temperature, the GB-A 2 093 647 teaches to provide the last-mentioned side with a heat sink having such a heat capacity that the temperature at the side onto which the heat sink has been applied does not increase to such an extent that overheating is the result. However, the heat sink causes the PTC to start performing its current-impeding function later.

The present invention provides an improved transient suppression system according to claim 1 in which the aforementioned disadvantages are overcome.

The transient suppressor device is placed in intimate thermal contact with the positive temperature coefficient thermistor. This allows heating of the transient suppressor device over the temperature at which the thermistor resistance exhibits large changes (~100°C) to result in current limiting. This current limiting effect will protect both the transient suppressor device and the subsequent circuitry from damage.

Those skilled in the art will readily be able to determine from the following explanations and by routine trial and experiment suitable junction configurations and doping levels which produce this decrease in voltage upon breakdown of the reverse biased junction.

Whilst, as will hereinafter be discussed, variation of one or more of the manufacturing parameters of the transient suppression system according to the invention enables systems to be manufactured consistently and reliably with breakdown voltages within a relatively wide range and up to relativ ly high values of the order of 150 to 200 V for example, for applications in the higher voltage areas the inv ntion further proposes, rather than the provision of a single transient suppressor, to cou-

ple together in series two or more transient suppressors each of a lower breakdown voltage rating. The resultant composite system has a breakdown voltage substantially corresponding to the sum of the breakdown voltages of the individual transient suppressors of the composite multi-device structure.

In order that the invention may be more fully understood embodiments thereof and their operating characteristics will be described by way of illustrative example and by way of contrast with prior art systems, reference being had to the accompanying drawings wherein:

Figures 1 and 2 show prior art transient suppression systems;

Figure 3 shows a transient suppression system according to the invention;

Figure 4 shows the electrical circuit elements of the transient suppression system according to Figure 3.

Figure 3 shows one application of the invention. A transient suppressor device 11 type L5C 150 CD manufactured by Semitron Cricklade Ltd, Cricklade Swindon, Wiltshire SN6 6HQ, GB, is soldered to a positive temperature coefficient thermistor 12 type manufactured by STC Components, GB. The transient suppressor device L5C 150 CD is of a type known as a foldback device (European Patent Application 82 304 718.8 = EP 0 088 179 A and US-Patent application Ser. No. 418 357).

Such a foldback device comprises a body of semiconductor material including a region of a first conductivity type disposed between regions of opposite conductivity type so as to define first and second spaced apart semiconductor rectifying junctions, first and second electrodes so arranged that when a potential difference is applied thereto one of said junctions is forward biased and the other of the junctions is reverse biased, the junctions being disposed to interact in such a manner that upon breakdown of the reverse biased junction from a relatively low conductivity state to a relatively high conductivity state and with an increase in the magnitude of the current flowing through the device, the magnitude of the potential difference developed across the electrodes decreases from that which causes said breakdown but does not decrease to a value less than a given non-zero value.

For an applied voltage V up to a given breakdown voltage V_b, the current flowing through the foldback device is the foldback device leakage current which is very small, for example 5 µA, and this has a significant effect on the operation of the circuit being protected. In this situation, one PN junction is forward biased, and the other PN junction is reverse biased but not such as to exceed its breakdown voltage.

When a voltage transient occurs in the supply voltage V, such as to apply to the device a voltage exceeding V_b, the reverse biased junction breaks down and conducts by means of the Avalanche effect. Consequently, the foldback device then provides a conductiv path for surg currents produced by the voltag transient, and the surge currents thus by-pass the circuit to b protected to prevent it being damaged. As the surge current increases, the voltage developed across the device rapidly reduces from the foldback device breakdown voltage V_b to a predetermined non-zero value V_m and as the current increases further, the voltage remains at the value V_m at least over a considerable range of surge current.

The voltage V_m may be selected by means of the doping process used to make the device and principally by control of the proximity to one another of the two PN junctions by control of the dopant diffusion depths and will be selected in dependance upon the characteristics of the circuit to be protected to be in excess of the minimum safe supply voltage for the circuit being protected.

Such a foldback device 11 is designed to breakdown at approximately 160 V. The voltage across the device 11 is then reduced to approximately 100 V due to the "foldback" action of the device 11.

The thermistor 12 is designed to change from a low resistance state (20 ohms) to a high resistance state (20 kohm) by heating from 100 °C to 150 °C. The assembly has three terminals 13, 14, 15 soldered to it with solder 16, 17, 18, and is coated with silicone rubber 19 to passivate the semiconductor junctions and to prevent flashover. Metal electrodes 20 are placed between the solder 16, 17, 18 and the respective surfaces of the devices 11, 12 in order to improve the electrical contact between the terminals 13, 14, 15 and the devices 11,12.

The resultant composite device has the circuit elements shown in Figure 4. One such device is required for the circuit shown in Figure 1 and two such devices are required for the circuit shown in Figure 2.

The terminals 13, 14 of the device of Figure 3, 4 are supplied with the electrical input and the terminals 14, 15 yield the corresponding electrical output.

An assembly of the type depicted in Figure 3 has shown excellent powers of circuit protection. The thermistor 12 protects against continuous excessive current. The transient suppressor 11 protects against short time constant surges. The thermistor 12 also reacts to excessive temperature due to power dissipation in the transient suppressor device 11. The combined unit therefore acts as a protector in intermediate fault conditions. Such behaviour was observed when subjecting the device to a 200 mA/240 V AC fault current for a duration of 5 minutes. If the thermistor 12 and transient suppressor 11 were not placed in thermal contact, the transient suppressor 11 would be degraded by this condition. The new innovative device limited the current to prevent excessive temperature rise in the transient suppressor device 11.

The transient suppression system does not only apply to Zener diode based semiconductor devices, but can apply to other transient absorption semiconductor devices such as thyristor based protectors.

Claims

1. Transient suppression system for use in telecommunication applications comprising at least one transient absorption semiconductor device (11) having at least two PN junctions for clamping short duration pulse voltages and being placed in intimate thermal contact with at least one positive temperature coefficient thermistor (12) for controlling the electrical power input to said at least one transient absorption seminconductor device (11) thereby preventing longer duration fault conditions damaging said transient absorption semiconductor device (11), characterized by a coating (19) to passivate the semiconductor junctions and to prevent flash-over.

2. Transient suppression system according to claim 1, characterized in that at least one transient absorption semiconductor device (11) is soldered to at least one of the at least one positive temperature coefficient thermistors (12).

3. Transient suppression system according to claim 1 or 2, characterized in that at least one positive temperature coefficient thermistors (12) is designed to change from a low resistance state to a high resistance state by heating from 100°C to 150°C.

4. Transient suppression system according to one of the claims 1 to 3, characterized in that at least one transient absorption semiconductor device (11) is designed to breakdown at approximately 160 V.

5. Transient suppression system according to claim 4, characterized in that after the breakdown of the at least one transient absorption semiconductor device (11) the voltage across the at least one transient absorption semiconductor device (11) is reduced to approximately 100 V due to a foldback action of the transient absorption semiconductor device (11).

6. Transient suppression system according to one of the claims 1 to 5, characterized by three terminals (13, 14, 15) soldered to it.

7. Transient suppression system according to one of the claims 1 to 6, characterized by at least one Zener diode based semiconductor device as a transient absorption semiconductor device (11).

8. Transient suppression system according to one of the claims 1 to 7, characterized by at least one thyristor based protector as a transient absorption semiconductor device (11).

Patentansprüche

1. System zum Unterdrücken eines transienten Vorganges zur Verwendung für Telekommunikationszwecke, mit wenigstens einem Spannungsbegrenzungselement (11), welches wenigstens zwei PN-übergänge aufweist, zum Klemmen von Spannungspulsen kurzer Zeitdauer, und welches Spannungsbegrenzungselement (11) in engem thermischen Kontakt mit wenigstens einem Thermistor (12) mit einem positiven Temperaturkoeffizienten des Widerstandswertes zur Steuerung der elektrischen Eingangsleistung zu dem wenigstens einen Spannungsbegrenzungselement (11) angeordnet ist, wodurch Störbedingungen von längerer Zeitdauer, die das Spannungsbegrenzungselement (11) schädigen, verhindert werden, gekennzeichnet durch einen Überzug (19) zur Passivierung der Halbleiter-übergänge und zur Verhinderung des Überspringens von elektrischen Funken.

2. System nach Anspruch 1, dadurch gekennzeichnet, daß wenigstens ein Spannungsbegrenzungselement (11) mit wenigstens einem Thermistor (12), der einen positiven Temperaturkoeffizienten des Halbleiterwiderstands aufweist, mit Lot verbunden ist.

3. System nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß wenigstens ein Thermistor (12), der einen positiven Temperaturkoeffizienten des Halbleiterwiderstands aufweist, so ausgebildet ist, daß er bei Erwärmung von 100°C auf 150°C von einem Zustand niedrigen Widerstands zu einem Zustand hohen Widerstands wechselt.

4. System nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß wenigstens ein Spannungsbegrenzungselement (11) so ausgebildet ist, daß es bei etwa 160 V einen Durchbruch erleidet.

5. System nach Anspruch 4, dadurch gekennzeichnet, daß nach dem Durchbruch von wenigstens einem Spannungsbegrenzungselement (11) die an diesem wenigstens einen Spannungsbegrenzungselement (11) anliegende Spannung auf etwa 100 V reduziert ist infolge einer Foldback-Aktion des Spannungsbegrenzungselements (11).

6. System nach einem der Ansprüche 1 bis 5, gekennzeichnet durch drei elektrische Anschlüsse (13, 14, 15), die mit dem System durch Lot verbunden sind.

7. System nach einem der Ansprüche 1 bis 6, gekennzeichnet durch wenigstens ein Halbleiterelement auf Zener-Dioden-Basis als Spannungsbegrenzungselement (11).

8. System nach einem der Ansprüche 1 bis 7, gekennzeichnet durch wenigstens ein Schutzelement auf Thyristor-Basis als Spannungsbegrenzungselement (11).

Revendications

1. Système de suppression de transitoires prévu pour l'utilisation dans des applications de télécommunications, comprenant au moins un dispositif à semiconducteurs d'absorption de transitoires (11) ayant au moins deux jonctions PN, pour éliminer des tensions sous forme d'impulsions de courte durée, et qui est placé en contact thermique intime avec au moins une thermistance à coefficient de température positif (12) pour commander la puissance électrique qui est appliquée à ce ou ces dispositifs à semiconducteurs d'absorption de transitoires (11), pour empêcher ainsi que des conditions de défaut de plus longue durée n'endommagent le dispositif à semiconducteurs d'absorption de transitoires (11), caractérisé par un enrobage (19) destiné à passiver les jonctions semiconductrices et à empêcher l'amorçage d'un arc en surface.

2. Système de suppression de transitoires selon la revendication 1, caractérisé en ce que au moins un dispositif à semiconducteurs d'absorption de

transitoires (11) est brasé sur l'une au moins des thermistances à coefficient de température positif (12).

3. Système de suppression de transitoires selon la revendication 1 ou 2, caractérisé en ce que au moins une thermistance à coefficient de température positif (12) est conçue de façon à passer d'un état à faible résistance vers un état à résistance élevée lorsqu'elle est chauffée de 100°C à 150°C.

4. Système de suppression de transitoires selon l'une quelconque des revendications 1 à 3, caractérisé en ce que au moins un dispositif à semiconducteurs d'absorption de transitoires (11) est conçu pour que son claquage se produise à environ 160 V.

5. Système de suppression de transitoires selon la revendication 4, caractérisé en ce que après le claquage de l'un des dispositifs à semiconducteurs d'absorption de transitoires (11), la tension aux bornes de ce dispositif à semiconducteurs d'absorption de transitoires (11) est réduite à environ 100 V à cause d'une action de retombée de tension du dispositif à semiconducteurs d'absorption de transitoires (11).

6. Système de suppression de transitoires selon l'une quelconque des revendications 1 à 5, caractérisé par trois bornes (13, 14, 15) qui sont brasées sur ce système.

7. Système de suppression de transitoires selon l'une quelconque des revendications 1 à 6, caractérisé par au moins un dispositif à semiconducteurs basé sur une diode Zener, en tant que dispositif à semiconducteurs d'absorption de transitoires (11).

8. Système de suppression de transitoires selon l'une quelconque des revendications 1 à 7, caractérisé par au moins un dispositif de protection basé sur un thyristor, en tant que dispositif à semiconducteurs d'absorption de transitoires (11).

1

FIG 1

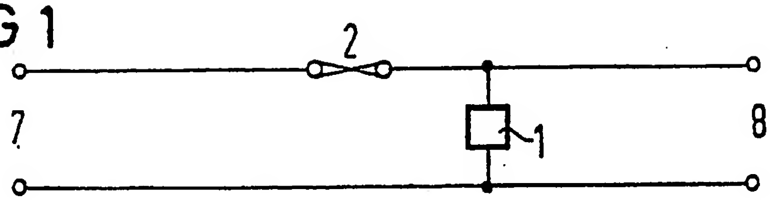

FIG 2

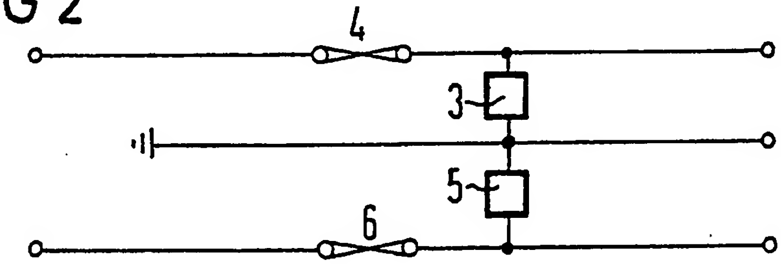

FIG 3

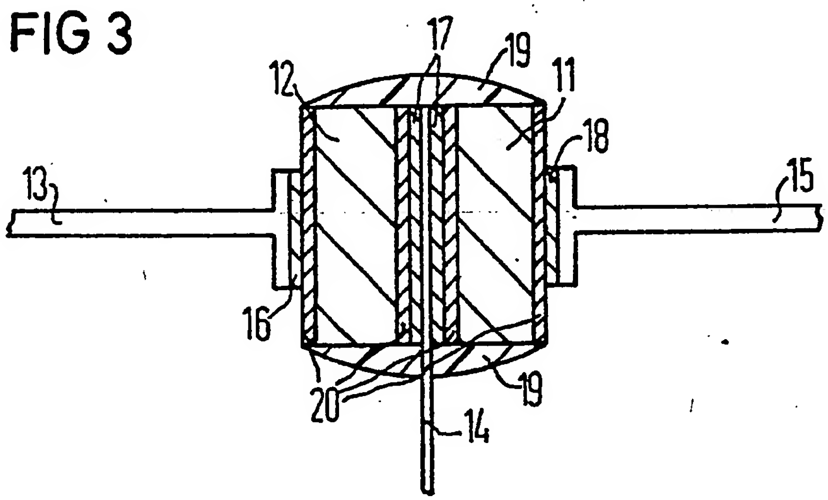

FIG 4